



The DANDELIONS-Field Campaign

**Ellen Brinksma
& the Dandelions team**

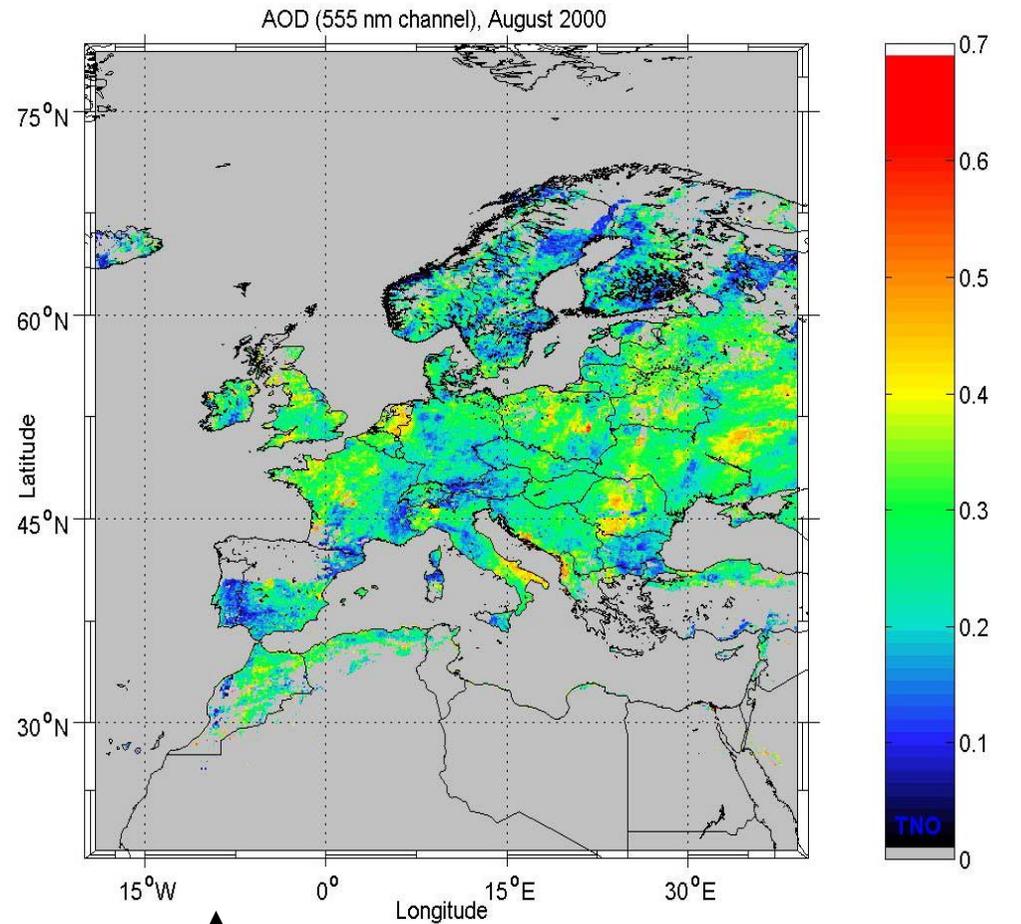
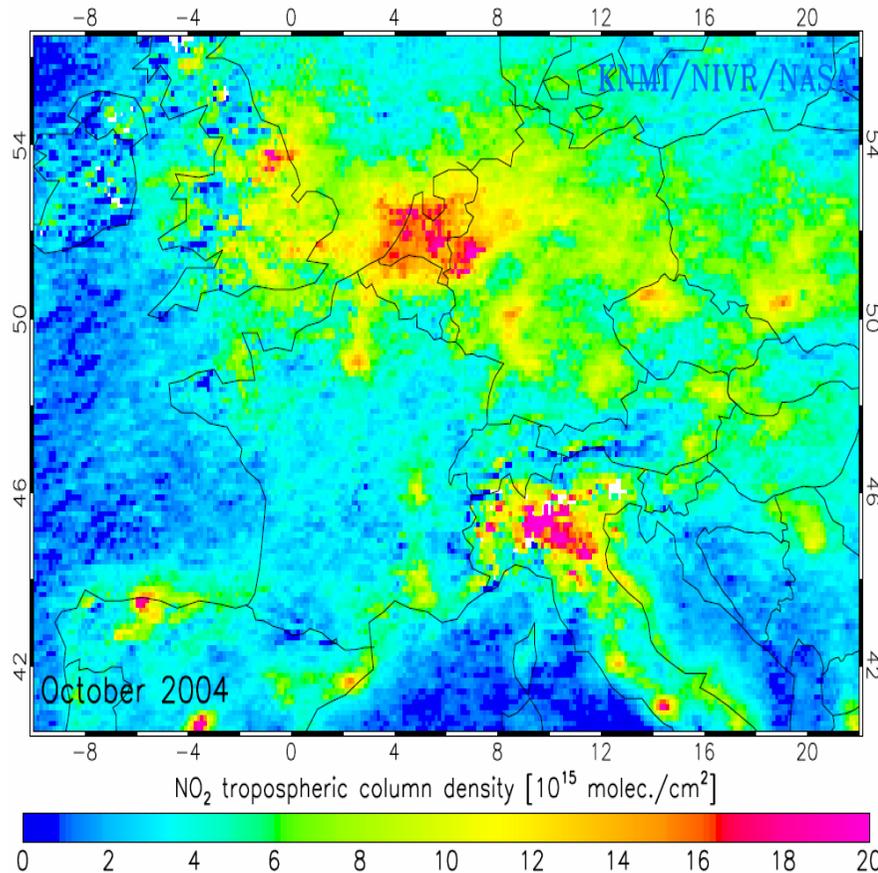
**Dutch Aerosol and Nitrogen Dioxide Experiments
for Validation of OMI and SCIAMACHY**

DANDELIONS Project



Satellite validation under
polluted conditions (Netherlands)

‘What are sources & transport of
tropospheric constituents?’



↑ ATSR Aerosol Optical Depth 555 nm (TNO)

← OMI tropospheric NO₂ (F. Boersma, KNMI)

DANDELIONS Campaign May-July 05

- I. OMI and SCIAMACHY aerosols, NO₂ (total & trop), ozone validation
- II. Intercomparison of groundbased NO₂ measurements
- III. Influence of aerosols on NO₂ retrievals (satellite & groundbased)

- Cabauw (51 N, 5 E)
- 5 “golden days” (extensive analysis) – cloud fraction < 0.2
- Many continuous measurements
- Suite of aerosol instruments
- Suite of NO₂ instruments
- Radiosondes, ozonesondes
- Brewer De Bilt (O₃, NO₂)
- Full meteorological info at location



Cabauw Experimental Site for Atmospheric Research

NO₂ Instrumentation



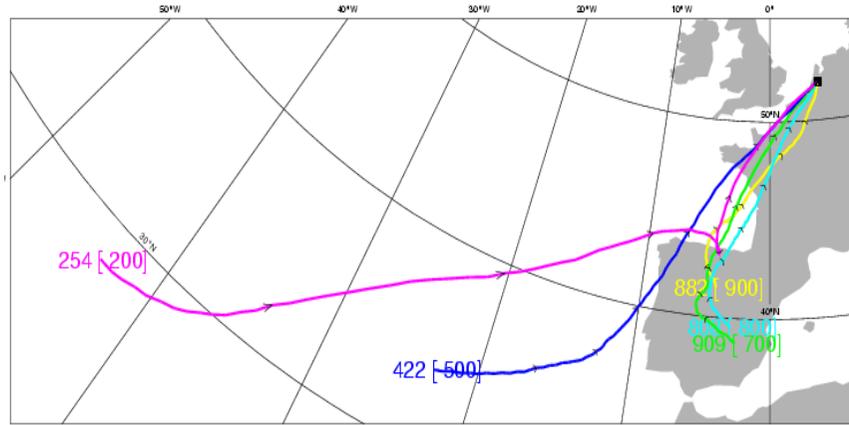
- OMI, SCIAMACHY
- RIVM lidar (DIAL) system – profile 2.5 km
- NL ground sampler network, includes Cabauw
- MAX-DOAS instruments yield tropospheric NO₂ columns, twilight total columns, limited altitude info
- Chimere, Aurora regional models
- UHeidelberg: Three telescopes, so three viewing directions

Five MAXDOAS systems (3 + 2 mini)

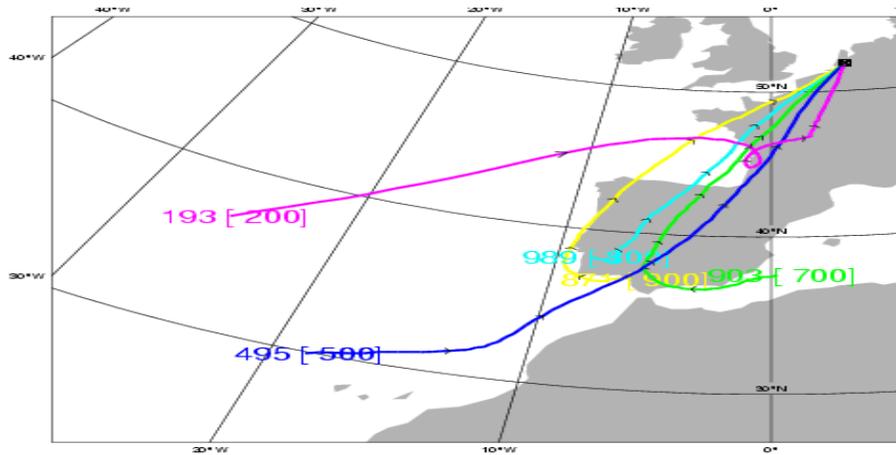
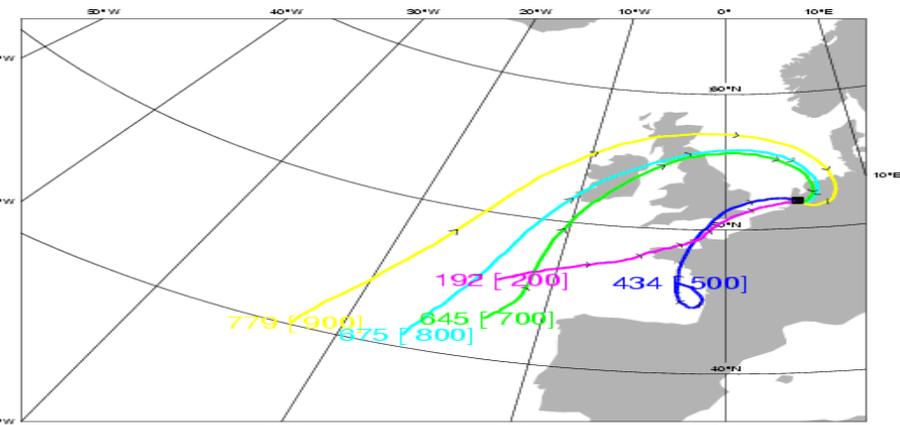


- BIRA systems 300 m from UBremen & UHeidelberg systems;
- KNMI miniMAXDOAS beside BIRA & (few days) beside UBremen
- BIRA mini system beside BIRA, later in tower (220 m)

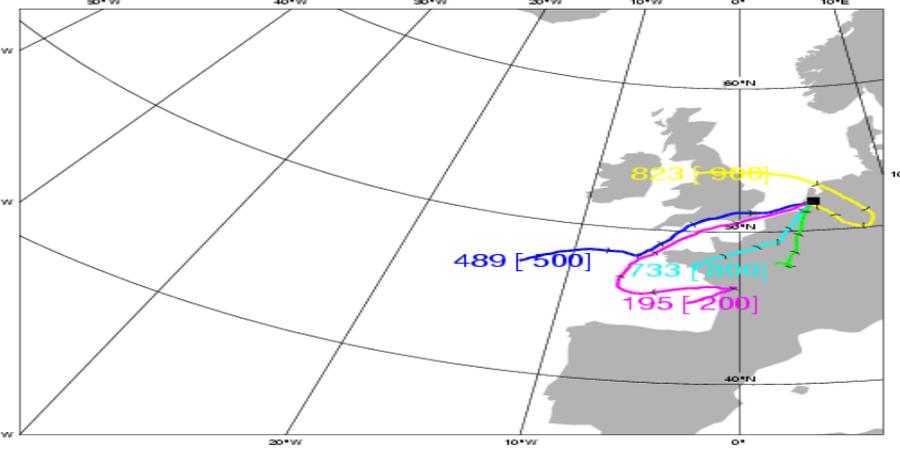
May 27, 2005



June 19, 2005



May 28, 2005



June 23, 2005

4-day backtrajectories @ 200,500,700,800,900 hPa

Continental pollution May 27, 28

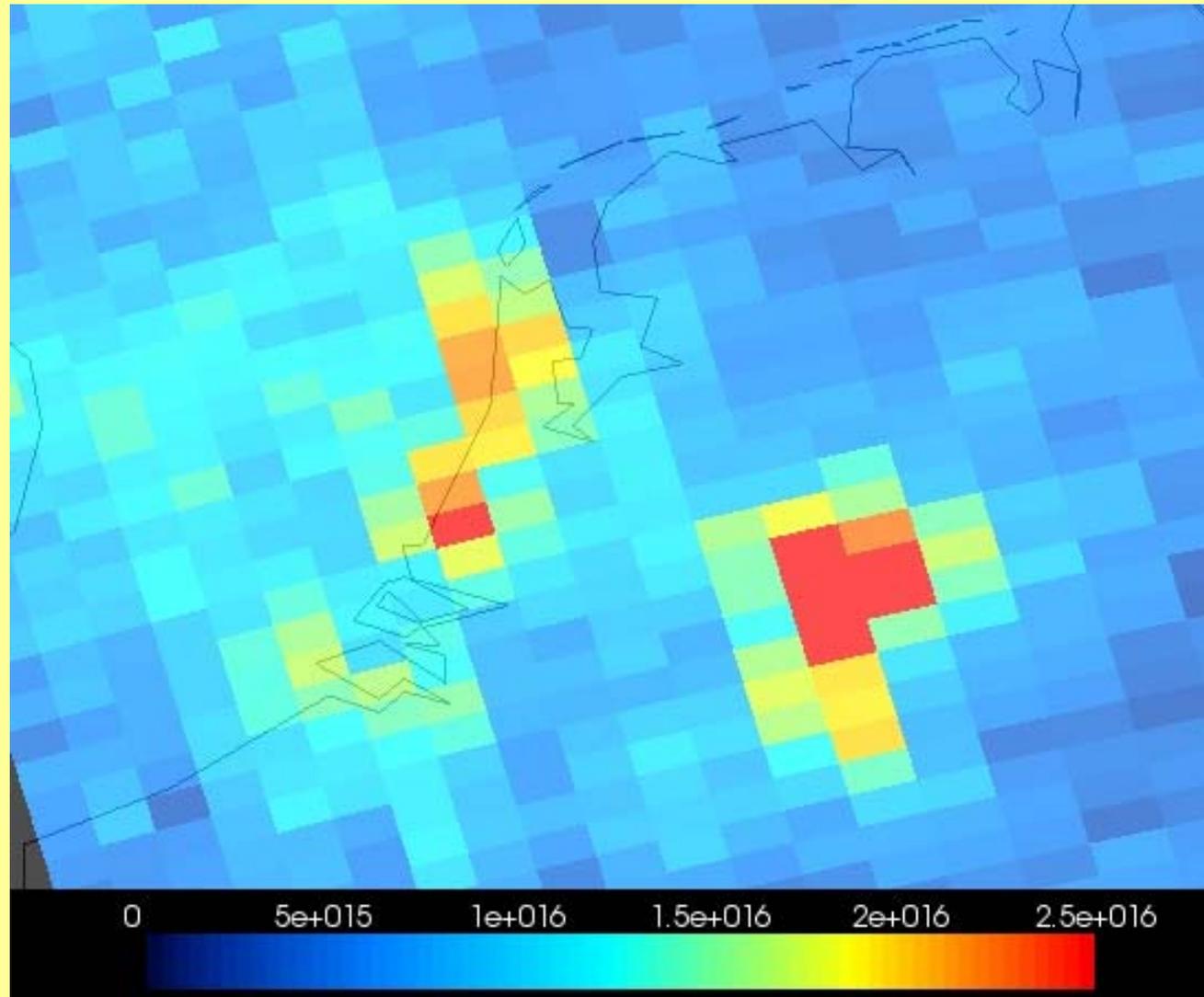
Very clean air June 19

Very polluted June 24

Courtesy of Rinus Scheele, KNMI

OMI total NO₂ on golden days

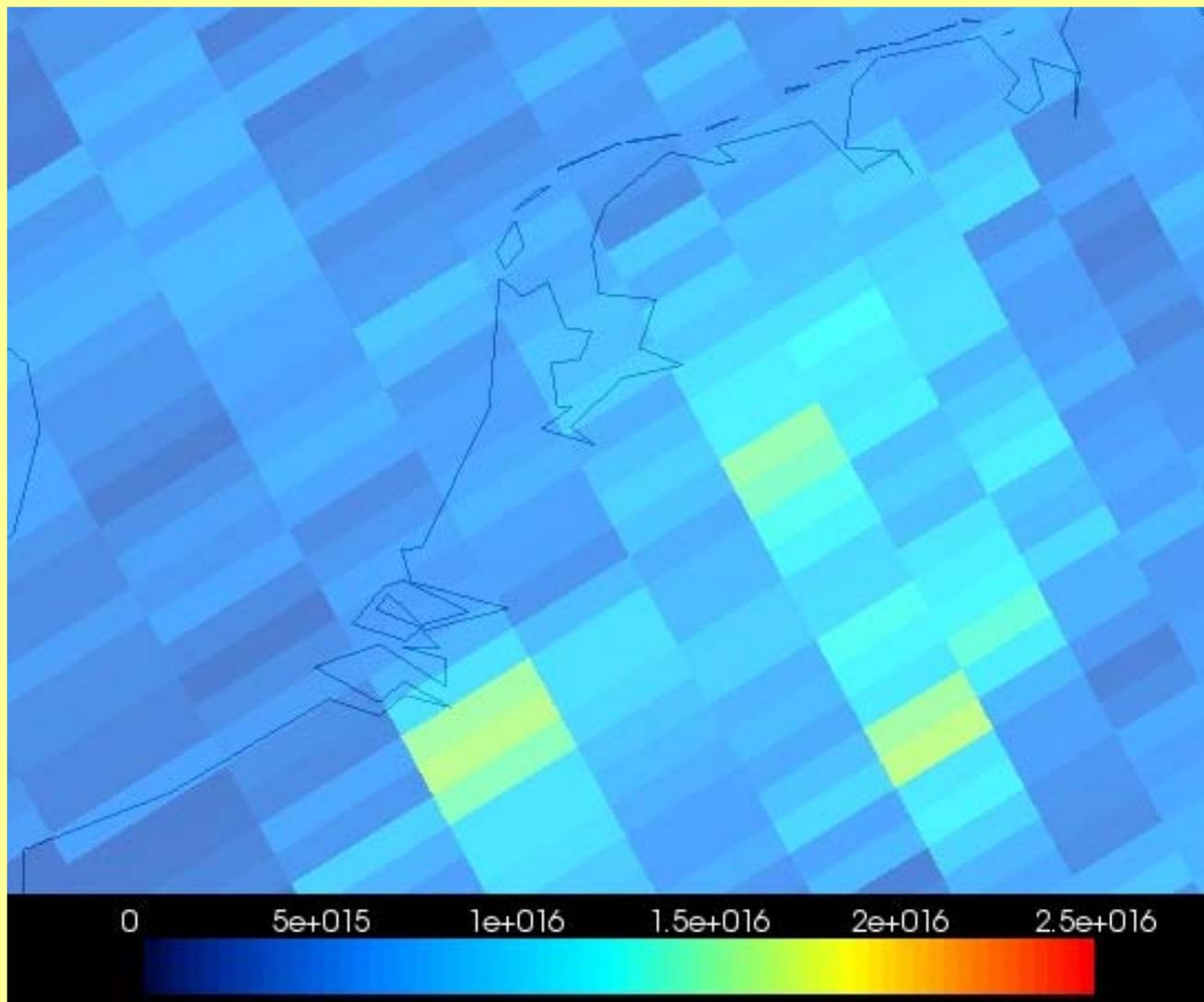
May 27



Pictures created using VISAN (www.science-and-technology.nl)

OMI total NO₂ on golden days

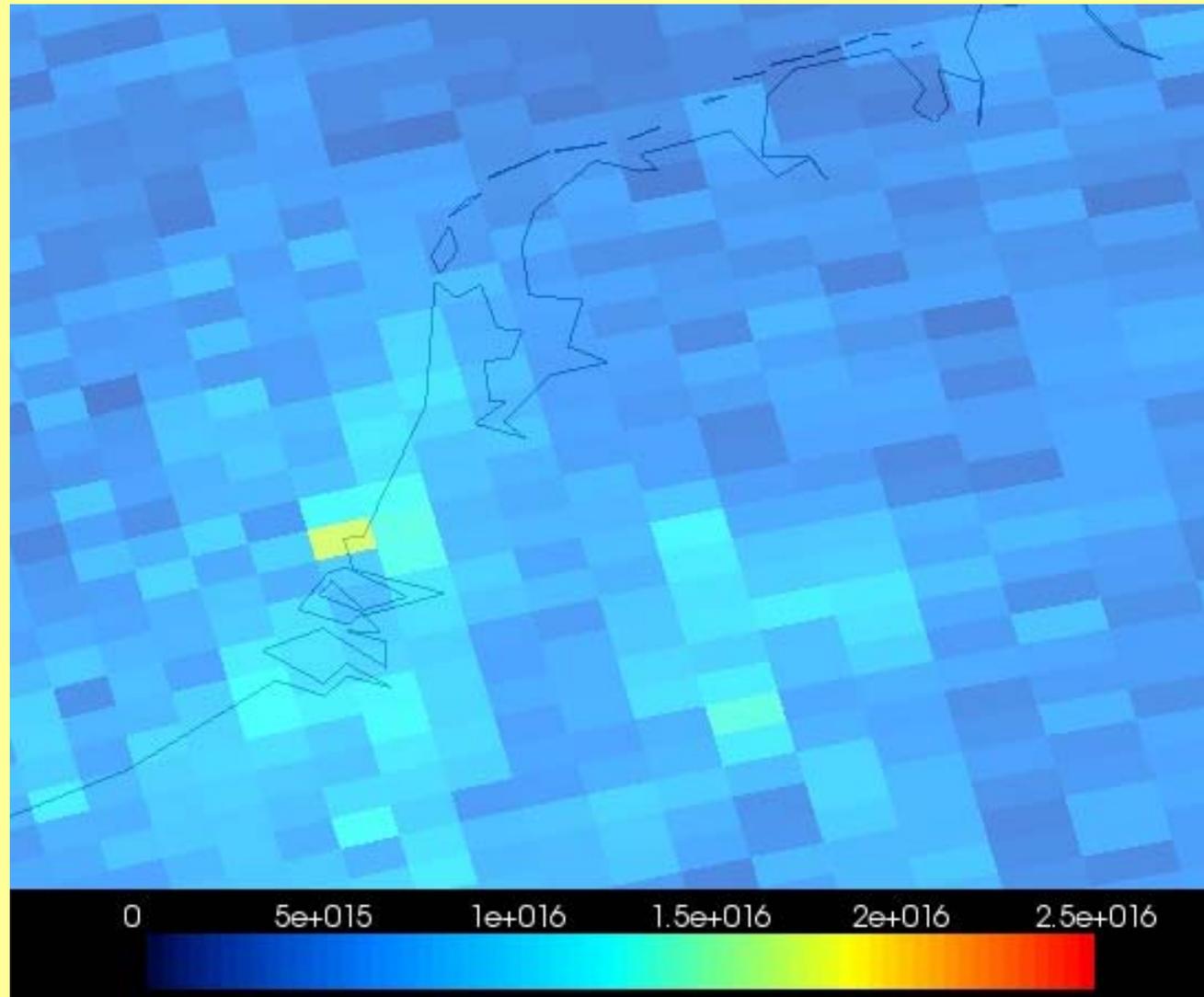
May 28



Pictures created using VISAN (www.science-and-technology.nl)

OMI total NO₂ on golden days

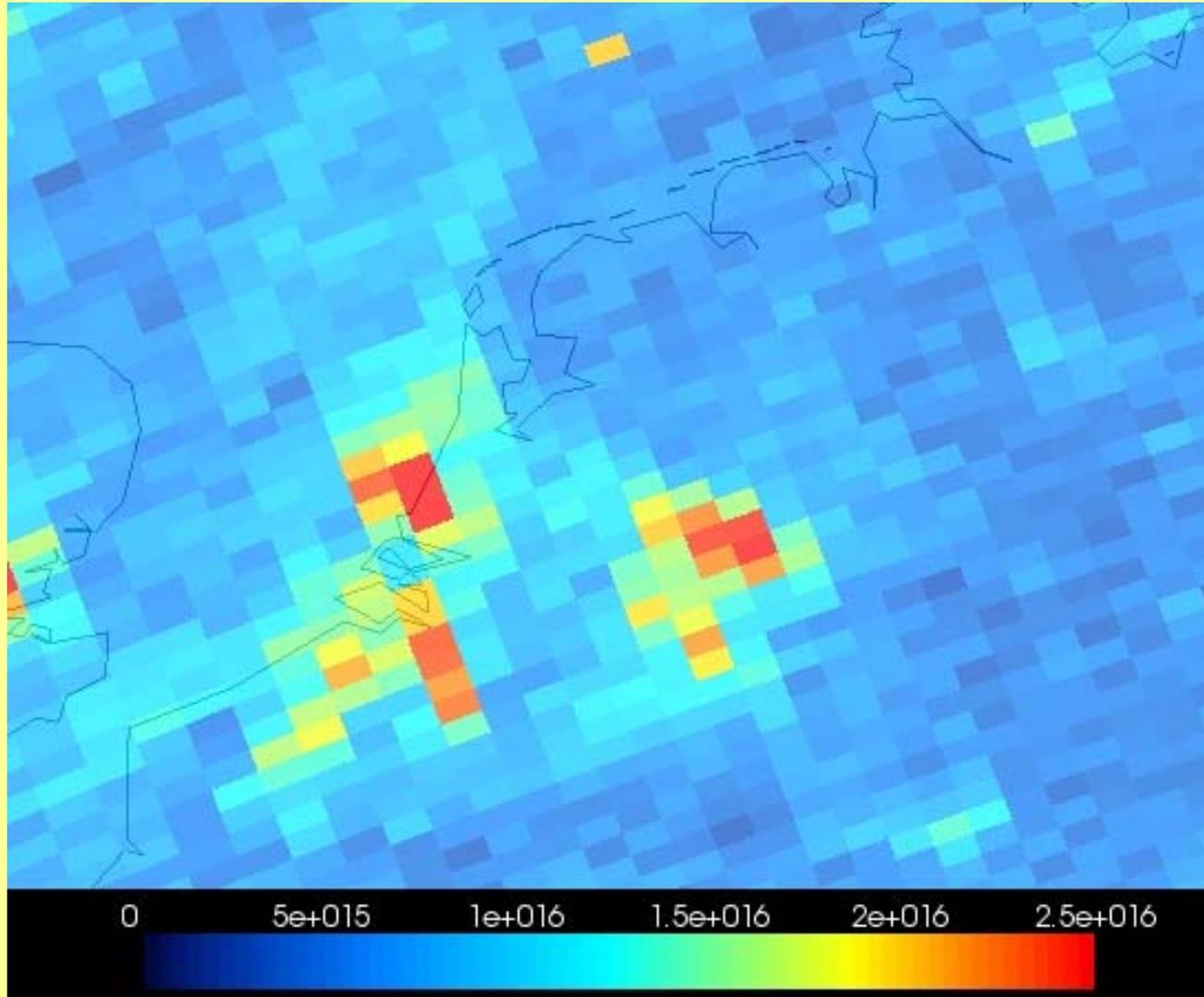
June 19



Pictures created using VISAN (www.science-and-technology.nl)

OMI total NO₂ on golden days

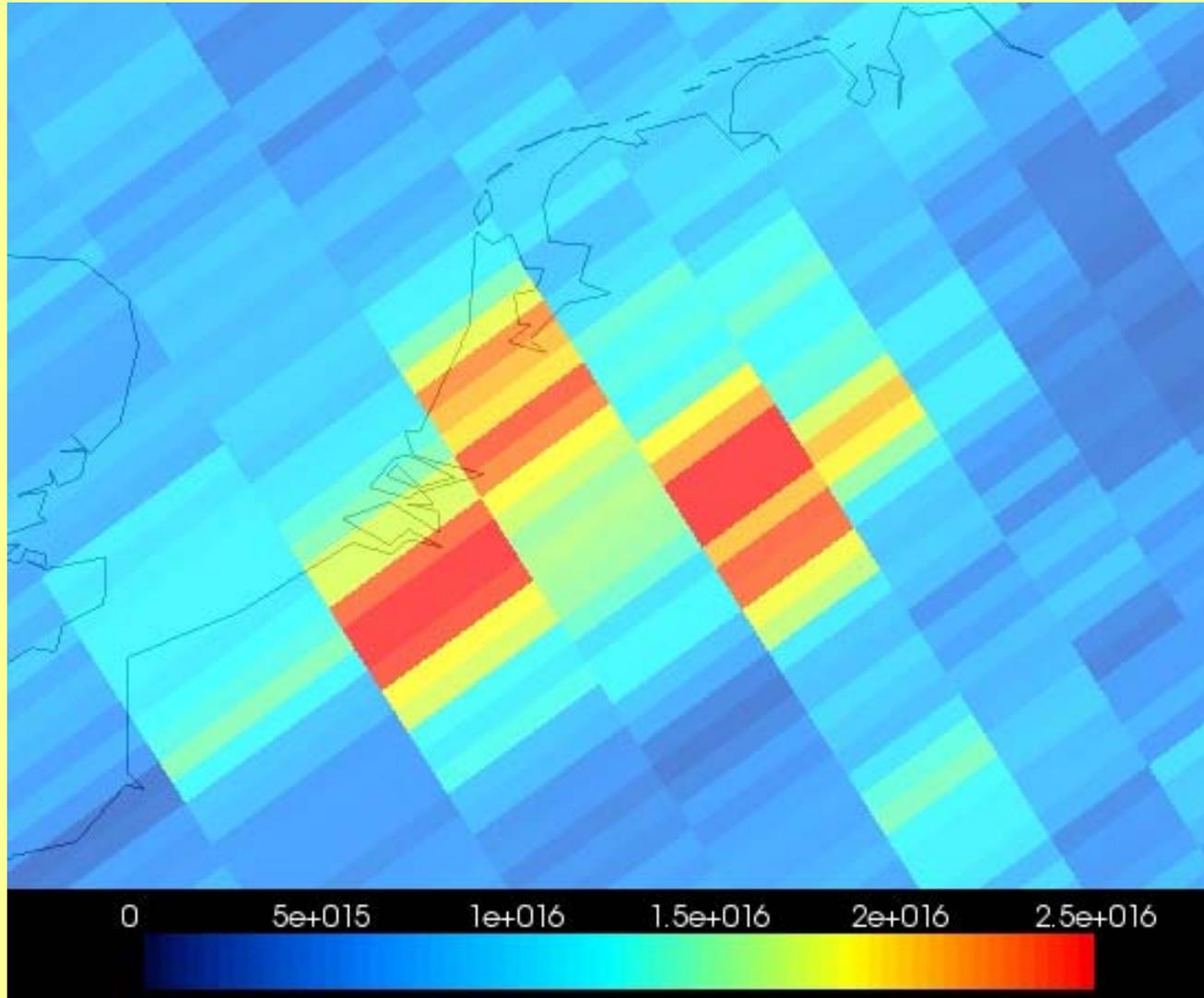
June 23



Pictures created using VISAN (www.science-and-technology.nl)

OMI total NO₂ on golden days

June 24



Note stretched pixels (side swath) – representativity Cabauw?

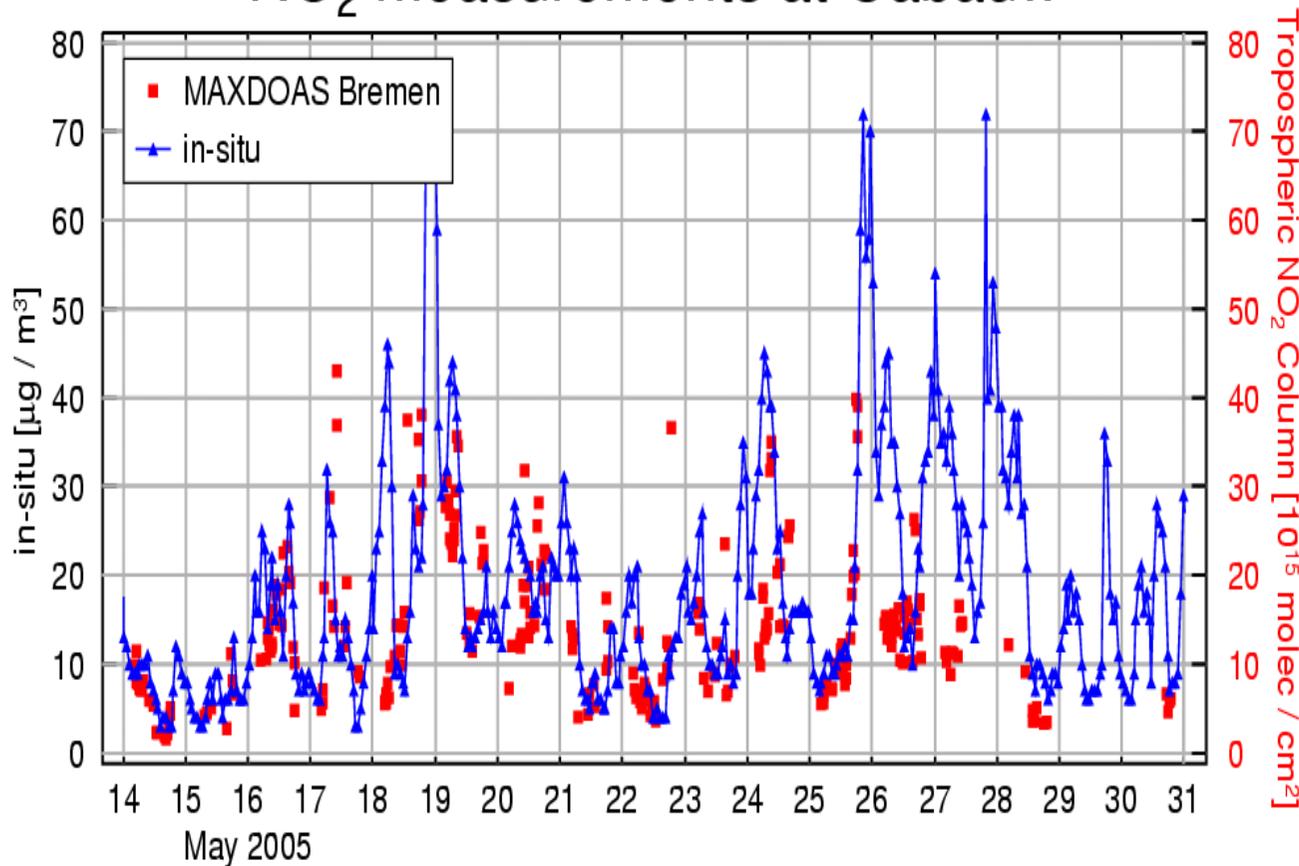


Nitrogen Dioxide Intercomparisons



IUP Bremen: Tropospheric NO₂ vs. in-situ

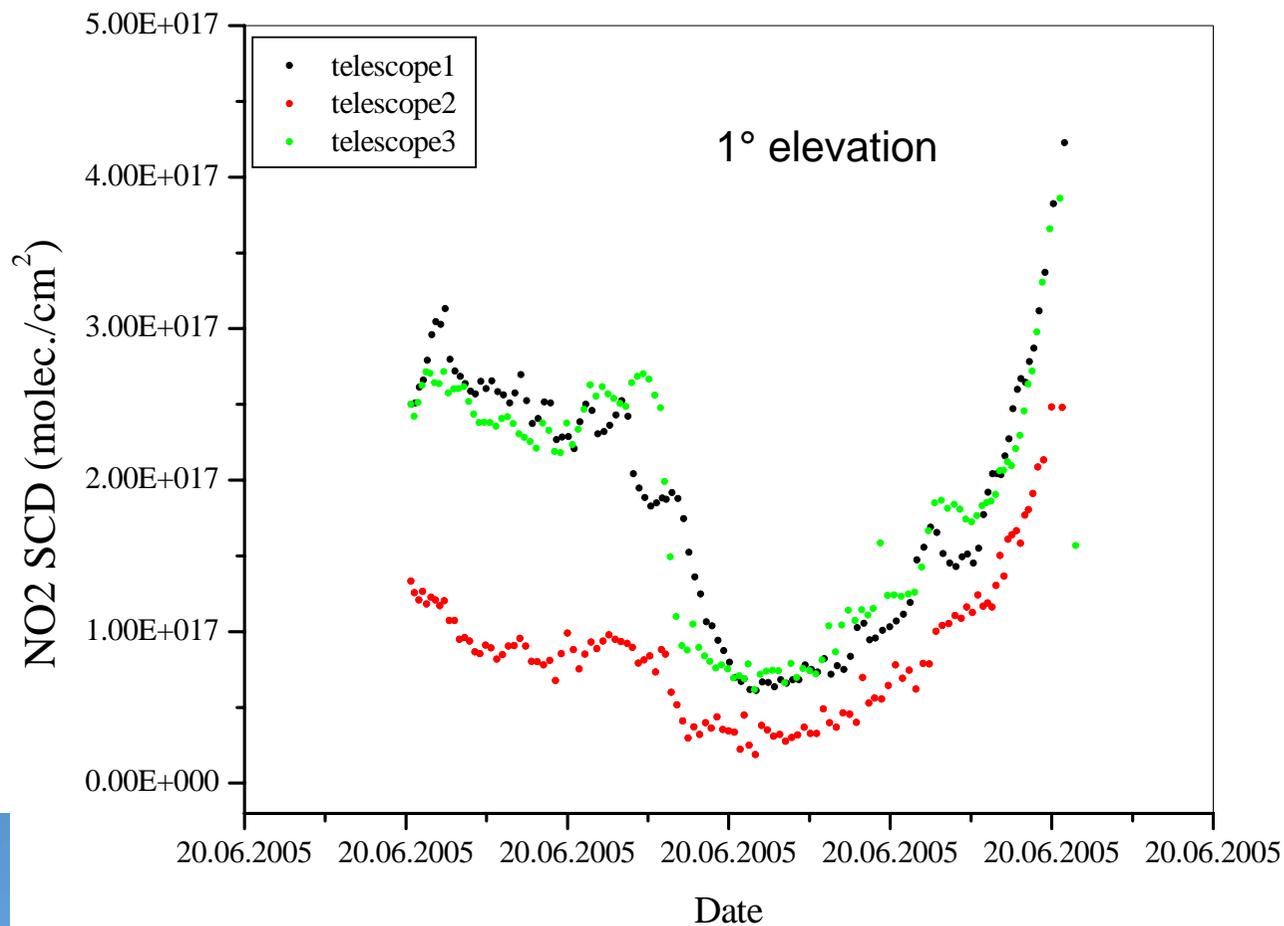
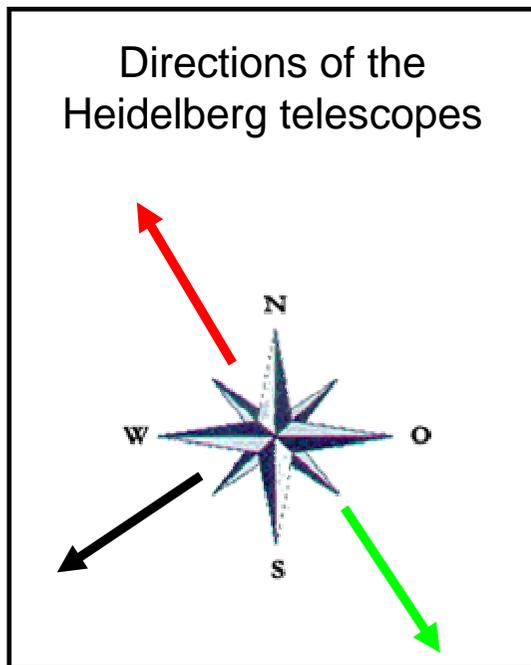
NO₂ measurements at Cabauw



Columns derived from simple approximations measurements for all days, not only for clear sky
high values
0.5 - 4 10¹⁶ cm⁻²
large variability but no random fluctuations

⇒ **Need for comparison with profile retrieval and correlative measurements**

Telescopes at different azimuth angles allow to detect horizontal gradients



Most days, more pollution towards S
Some days, no horizontal gradients

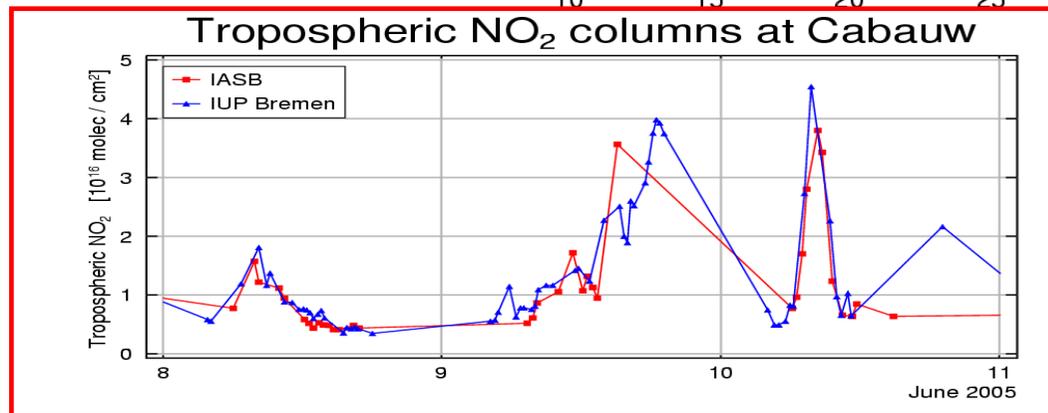
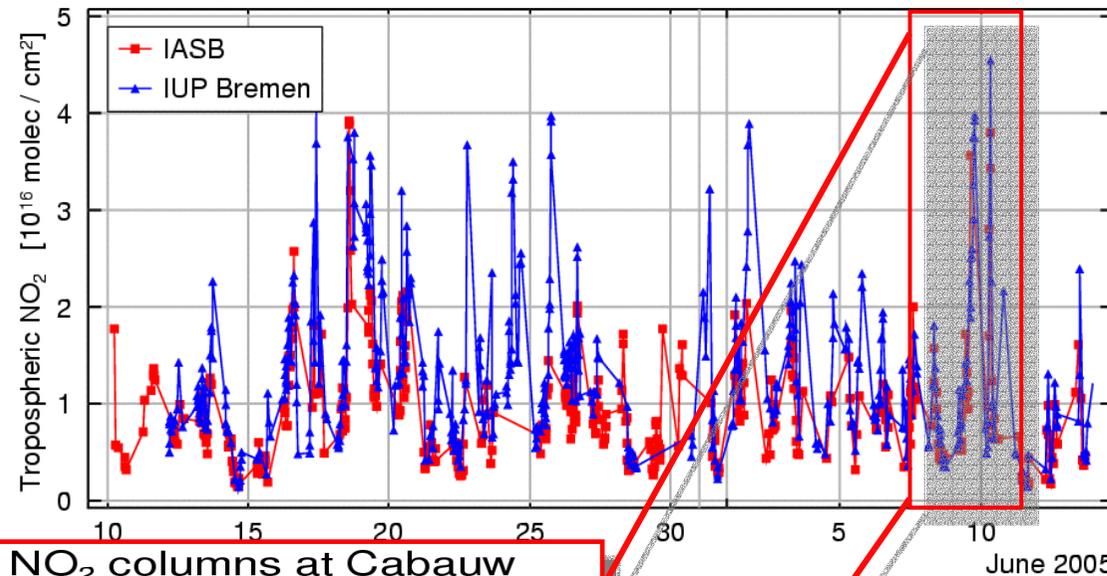
Heidelberg telescopes

Thomas Wagner,
Ossama Ibrahim

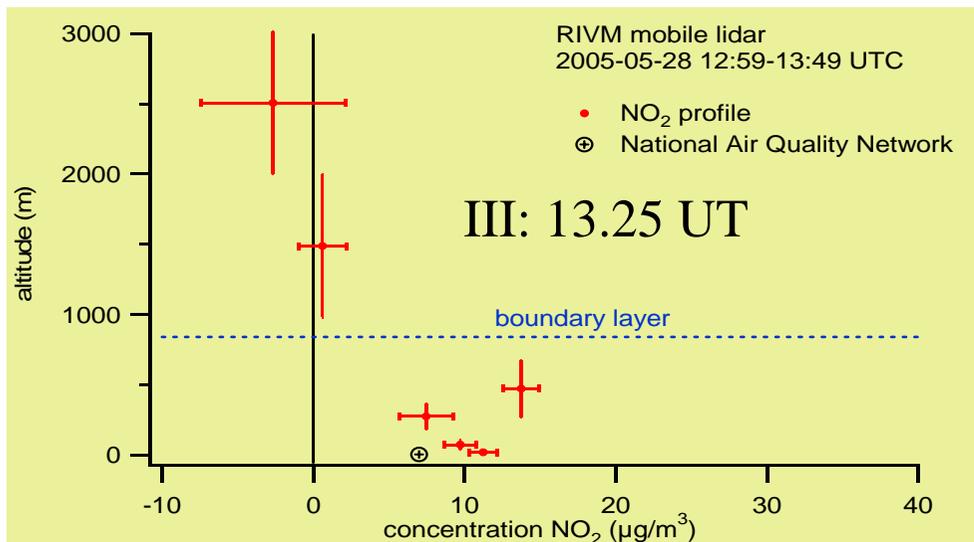
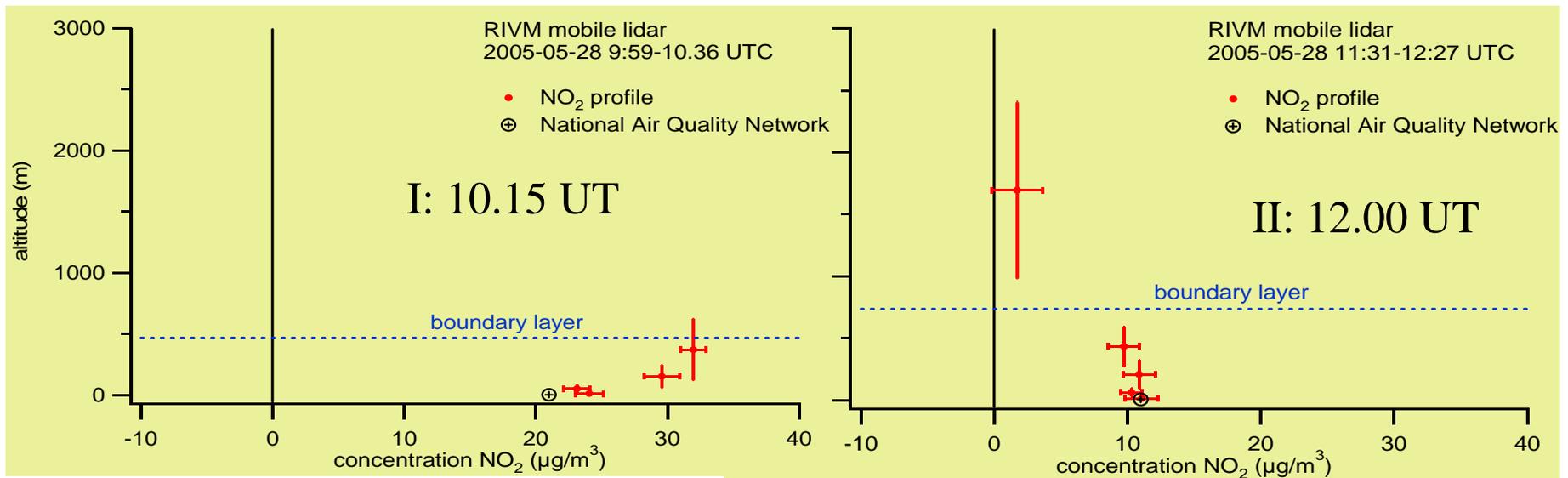


Comparison Bremen & BIRA

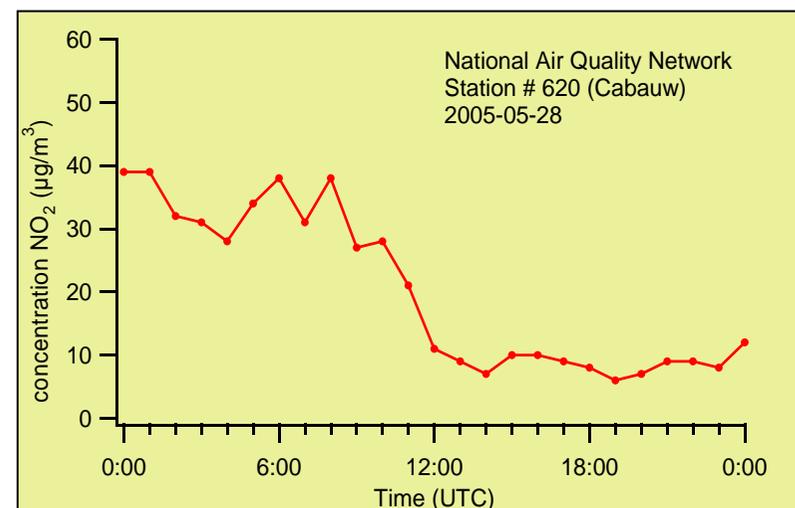
Tropospheric NO₂ columns at Cabauw



- different viewing directions, different time of measurement
- => very good consistency!

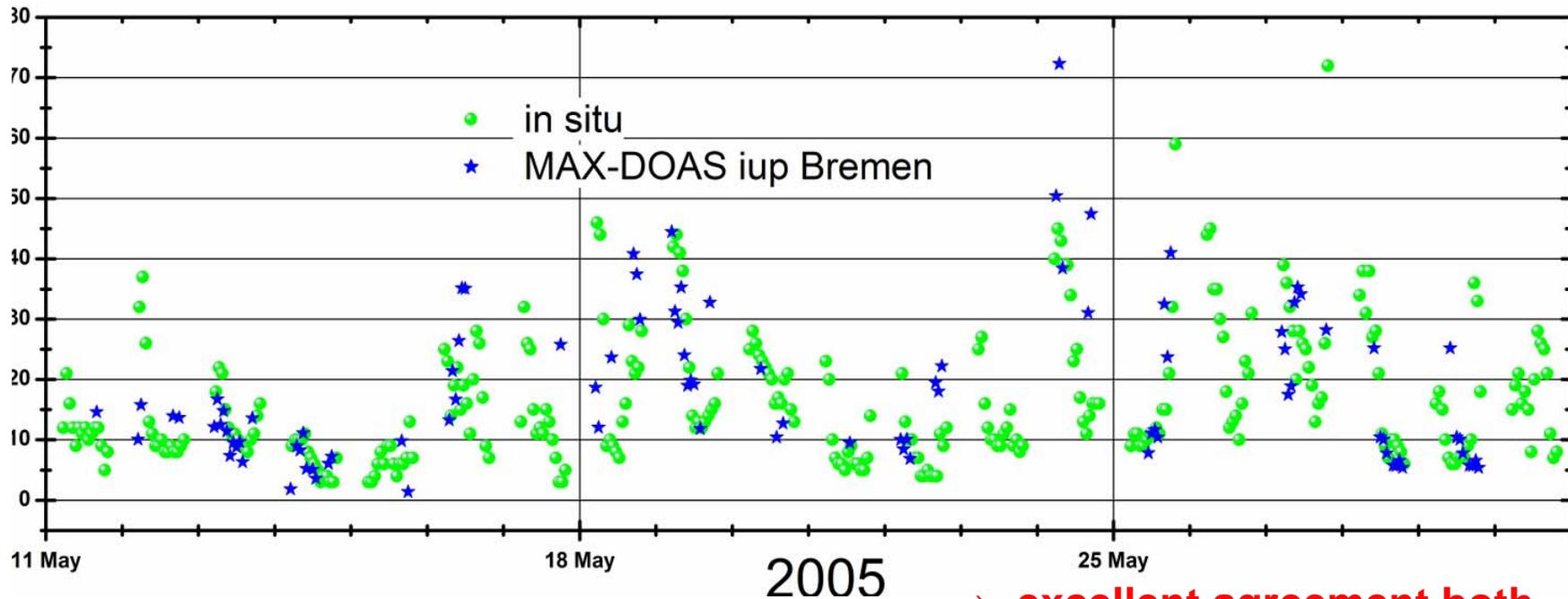


May 28 (polluted “golden day”)
Consecutive NO₂ profiles (lidar)
In situ sampler



Note large variation in profile shape, and
rapid decrease of ground concentrations

Comparison in-situ & IUP Bremen MAXDOAS



- BREAM profile retrieval
- value for lowest 50 m
- aerosol OD from O_4 signal
- data selection based on NO_2 and O_4 consistency with RTM simulation for all viewing directions

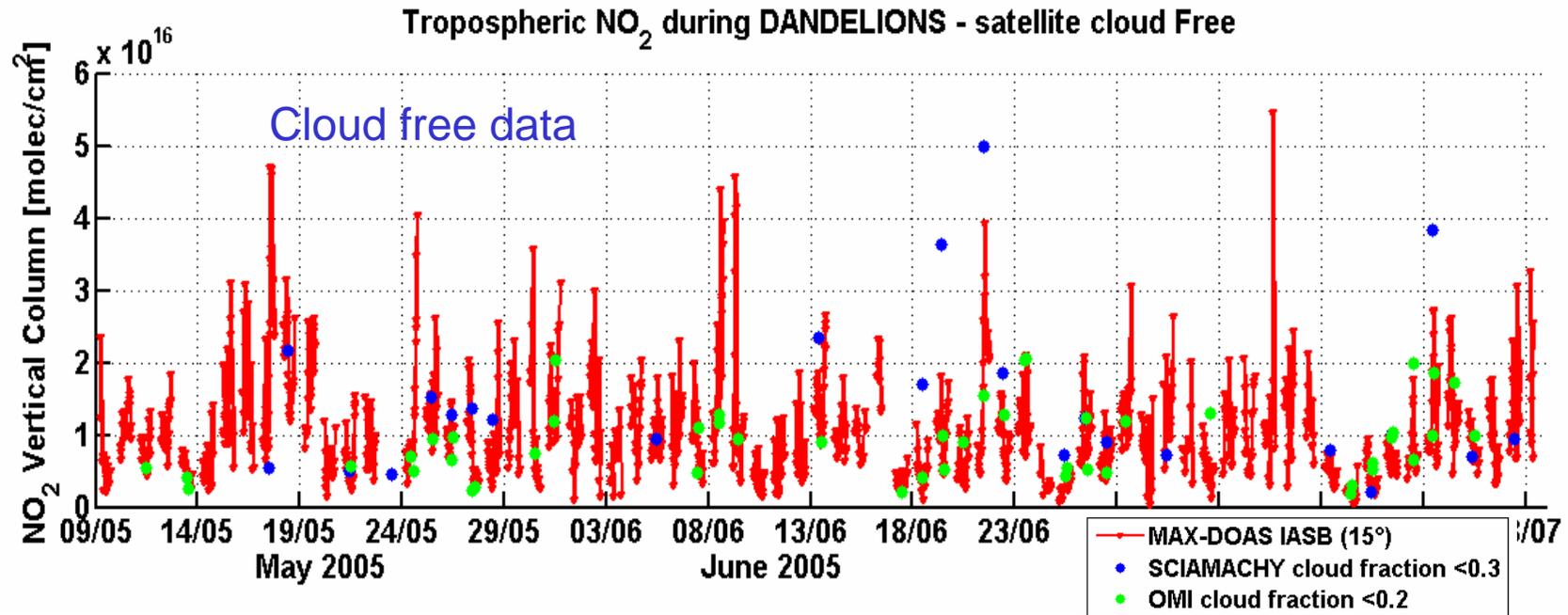
⇒ **excellent agreement both in relative and absolute terms**

⇒ **no scaling or free parameters**

⇒ **MAXDOAS can link in-situ and satellite measurements**

(F.Wittrock / A. Richter)

MAXDOAS – OMI – SCIAMACHY series



NO₂ tropospheric vertical columns:

- IASB MAX-DOAS: geometrical approximation
- Satellites: closest pixels within 200km over Cabauw and cloud selection

Groundbased MAXDOAS - BIRA/IASB, courtesy M. van Roozendaal et al.

BIRA MAXDOAS – satellite comparisons

OMI

Correlation coef:

All: 0.21

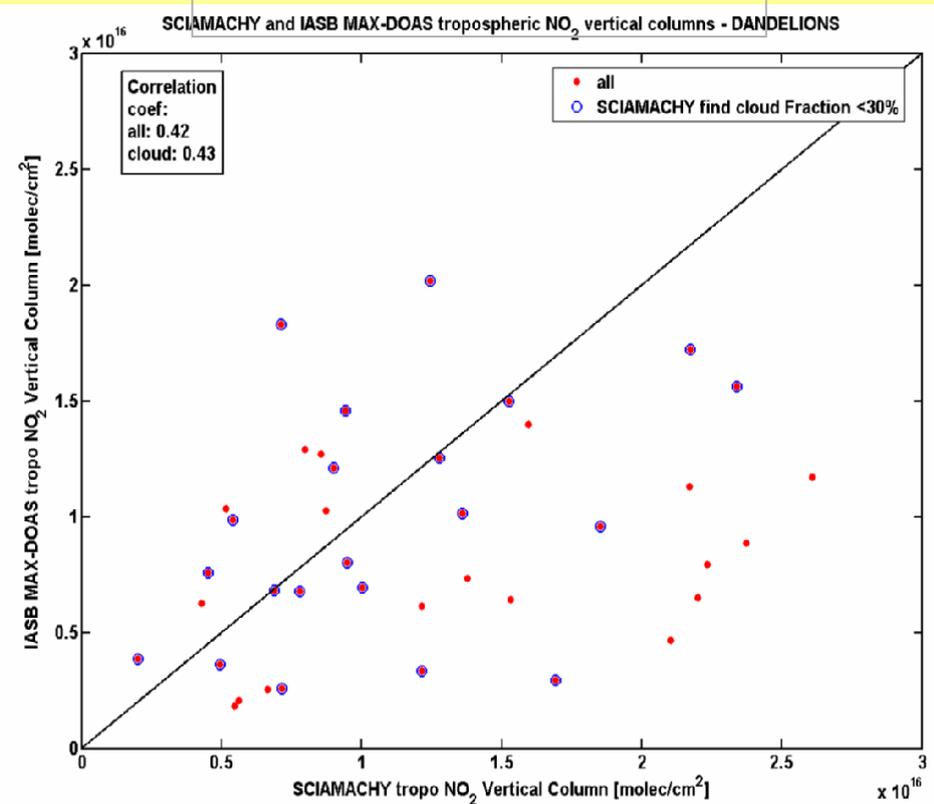
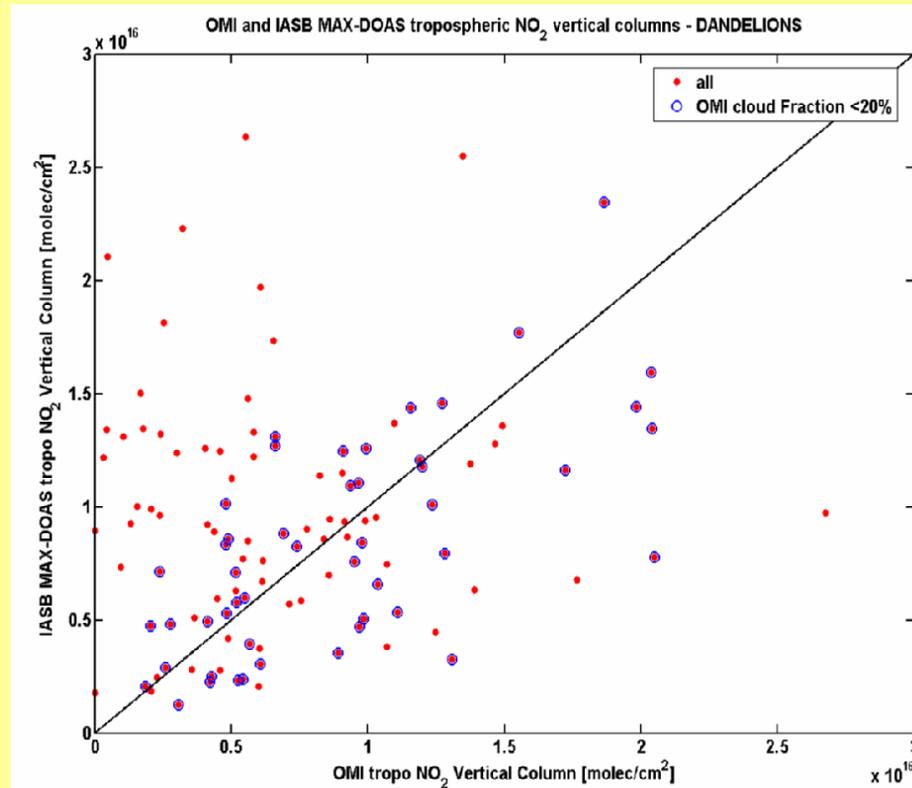
Cloud free: 0.67 (f<0.2)

SCIAMACHY

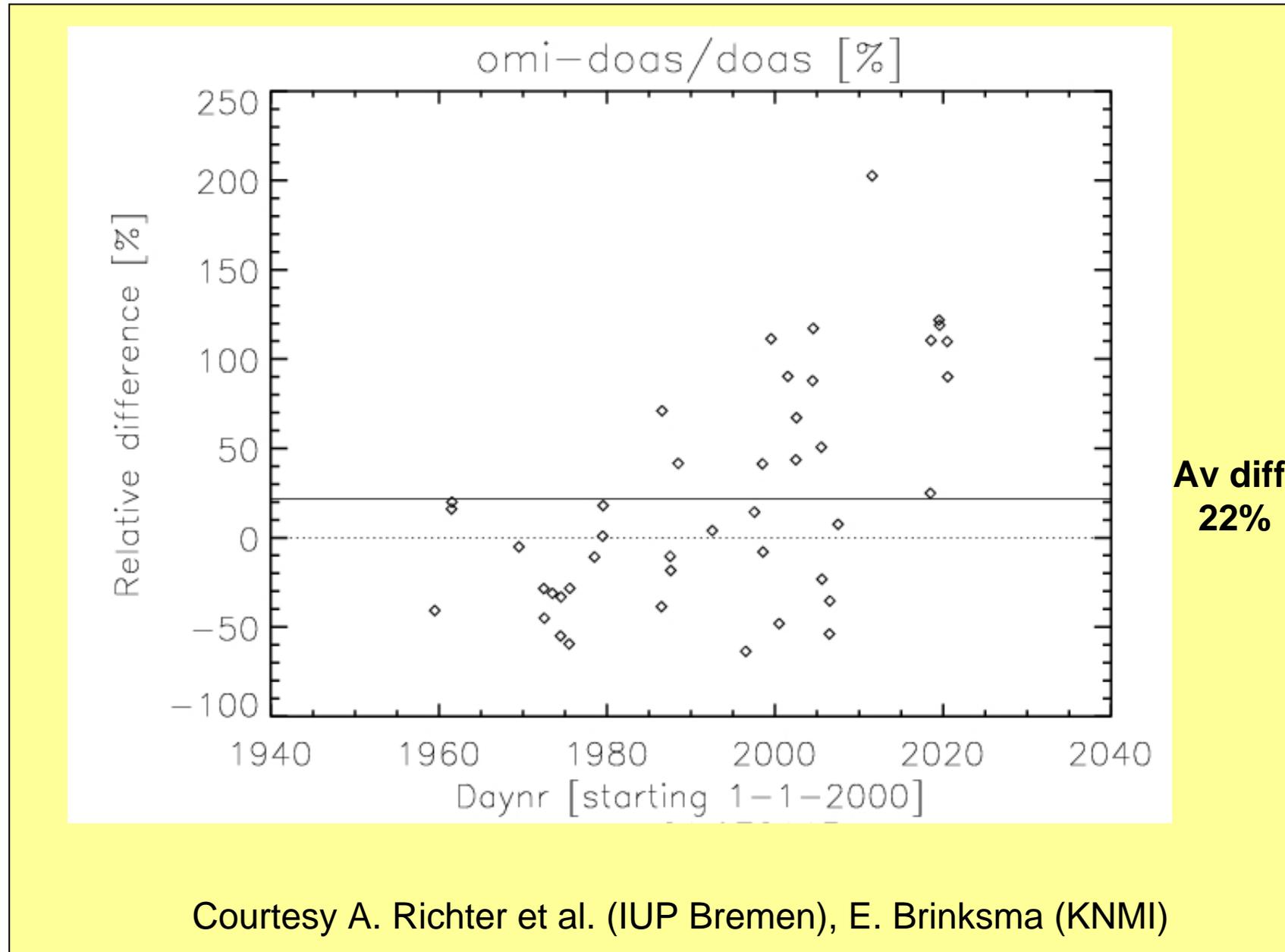
Correlation coef:

All: 0.42

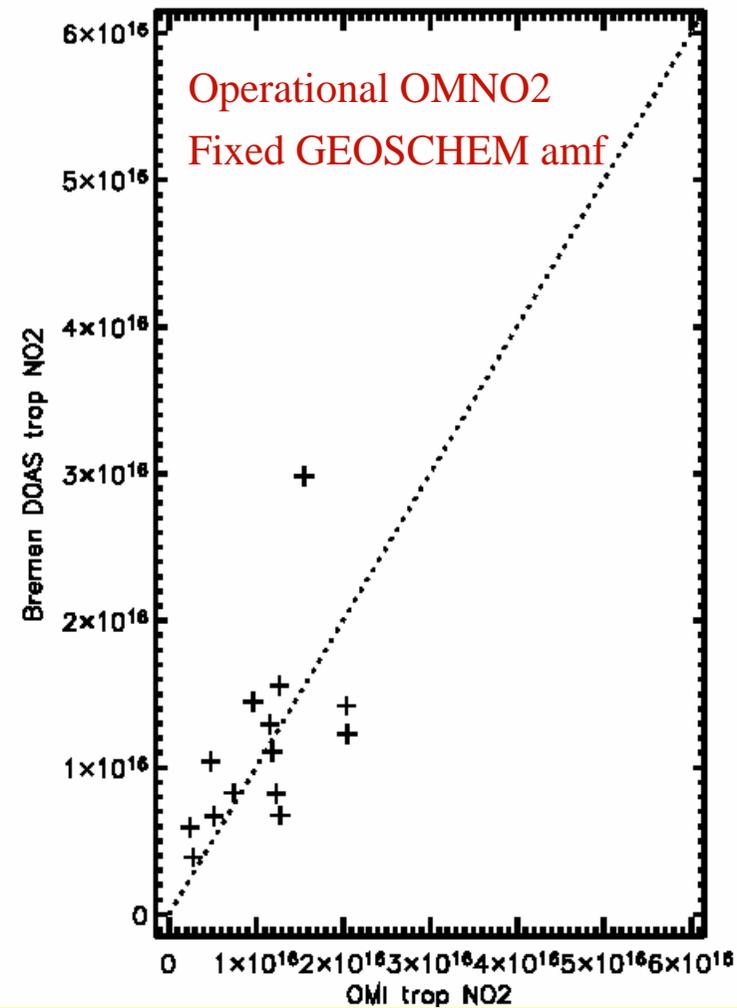
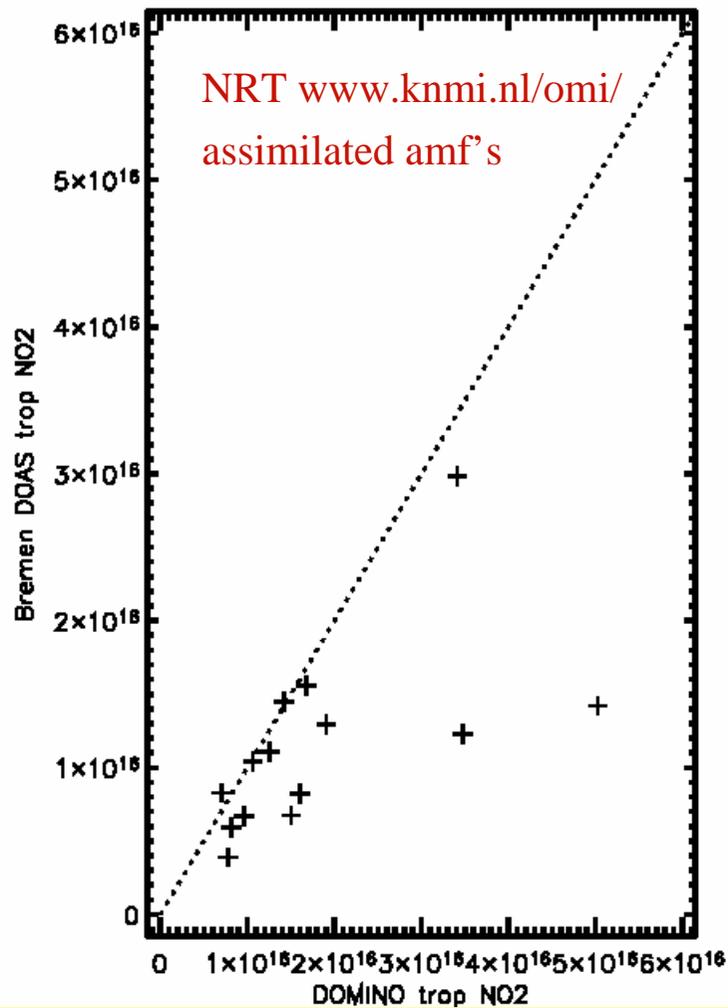
Cloud free: 0.43 (f<0.3)



IUP Bremen MAXDOAS – OMI comparisons



IUP Bremen MAXDOAS – OMI comparisons



R=0.59 n=14 avdif=+65%

R=0.55 n=14 avdif=-2%

9-week campaign: R=0.63 n=44 avdif=+22%

A. Richter et al. (IUP Bremen), F. Boersma, E. Brinksma (KNMI)



Conclusions & Outlook



Conclusions

- Campaign was very successful
- Satellite & MaxDOAS trop NO₂ agree well
- MaxDOAS instruments compare well when side-by-side, reasonable if 300 m apart
- NO₂ field often higher towards South, many short-time fluctuations seen
- Unique NO₂ profiles 0-2.5 km (lidar, MAXDOAS)
- Much more work on details needed ... pixel size issues (representativity), swath angle dependence, homogeneity of NO₂ field, distance criterion
- Influence of aerosols on groundbased retrievals?

Outlook

- NO₂ profile comparisons: MAXDOAS, lidar, OMI, SCIAMACHY, Chimere regional model, Aurore hi-res model
- Closure-type studies for five golden days
- Detailed interpretation of comparisons satellite & groundbased total and tropospheric columns

Campaign report on MaxDOAS results available
(Accent-Troposat 2 website)

The Dandelions team:

KNMI: E. Brinksma, P. Levelt, R. Rothe, E. Worrell, A. Swinkels, S. Warmer, A. Piters, R. Agterberg, M. Allaart, M. Kroon, J. de Vroom, H. Eskes, F. Boersma, P. Veeffkind, N. Léonard-Blond, C. van Oort, H. Welberge, and many others ...

TNO The Hague: G. de Leeuw, L. Curier, M. Moerman

RIVM: D. Swart, S. Berkhout, R. van der Hoff, H. Bergwerff, A. Apituley and others

BIRA-IASB: M. van Roozendael, C. Fayt, C. Hermans, G. Pinardi

IUP Heidelberg: T. Wagner, O. Ibrahim

IUP Bremen: A. Richter, H. Oetjen, F. Wittrock



Acknowledgments:

AT-2 for providing travel grants

Dutch User Support (GO) programme for project funding

Guidance meteorologists & computer technicians at KNMI





Backup Material

Interpretation of comparison results

Work in progress on:

- Pixel size => Cabauw representative for satellite pixel?
- Swath angle dependence (OMI)
- Influence of clouds
- Influence of NO₂ profile (amf) – compare model, lidar, MAXDOAS

Measurement statistics

Operator-assisted:

- NO₂ lidar 14 days
- ozone sondes 14
- radio sondes 8.

Continuous records:

- MaxDOAS (3 instruments)
- CIMEL (2 instruments)
- miniDOAS (2 instruments), for part of campaign
- permanent instruments at Cabauw.

Satellite overpasses (within 51 days, May 12–Jun 30):

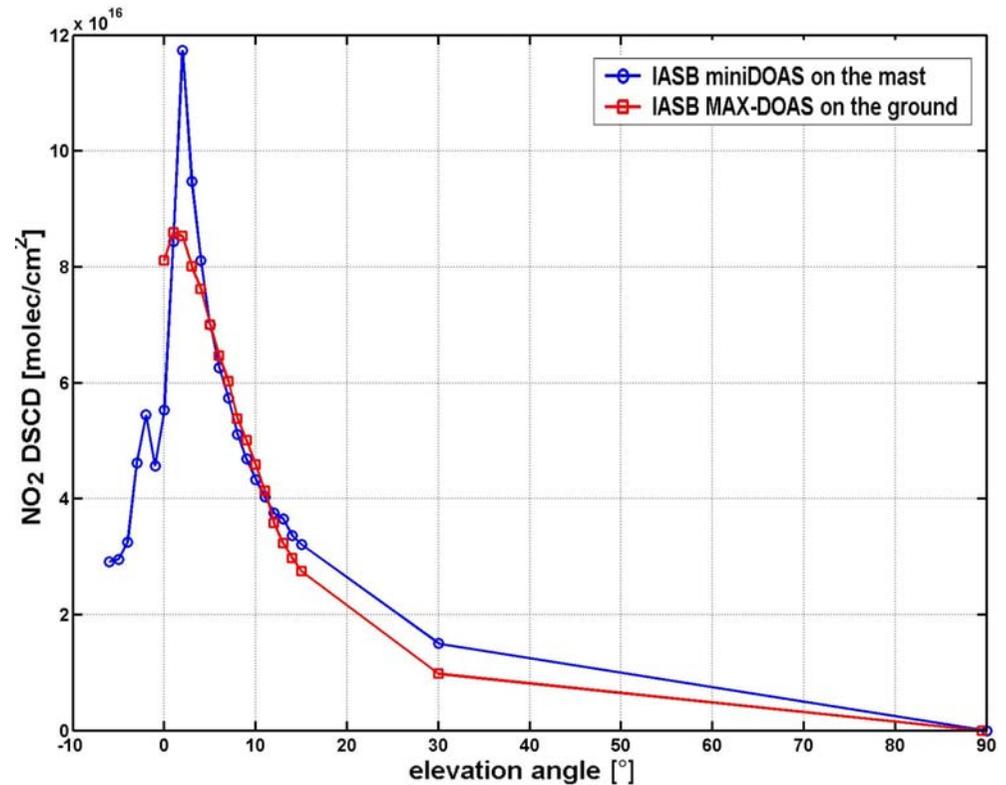
- OMI 79
- SCIAMACHY 24
- AATSR 16.

MAX-DOAS 0 & 220 m

5 July 2005: installation on top of the Cabauw mast

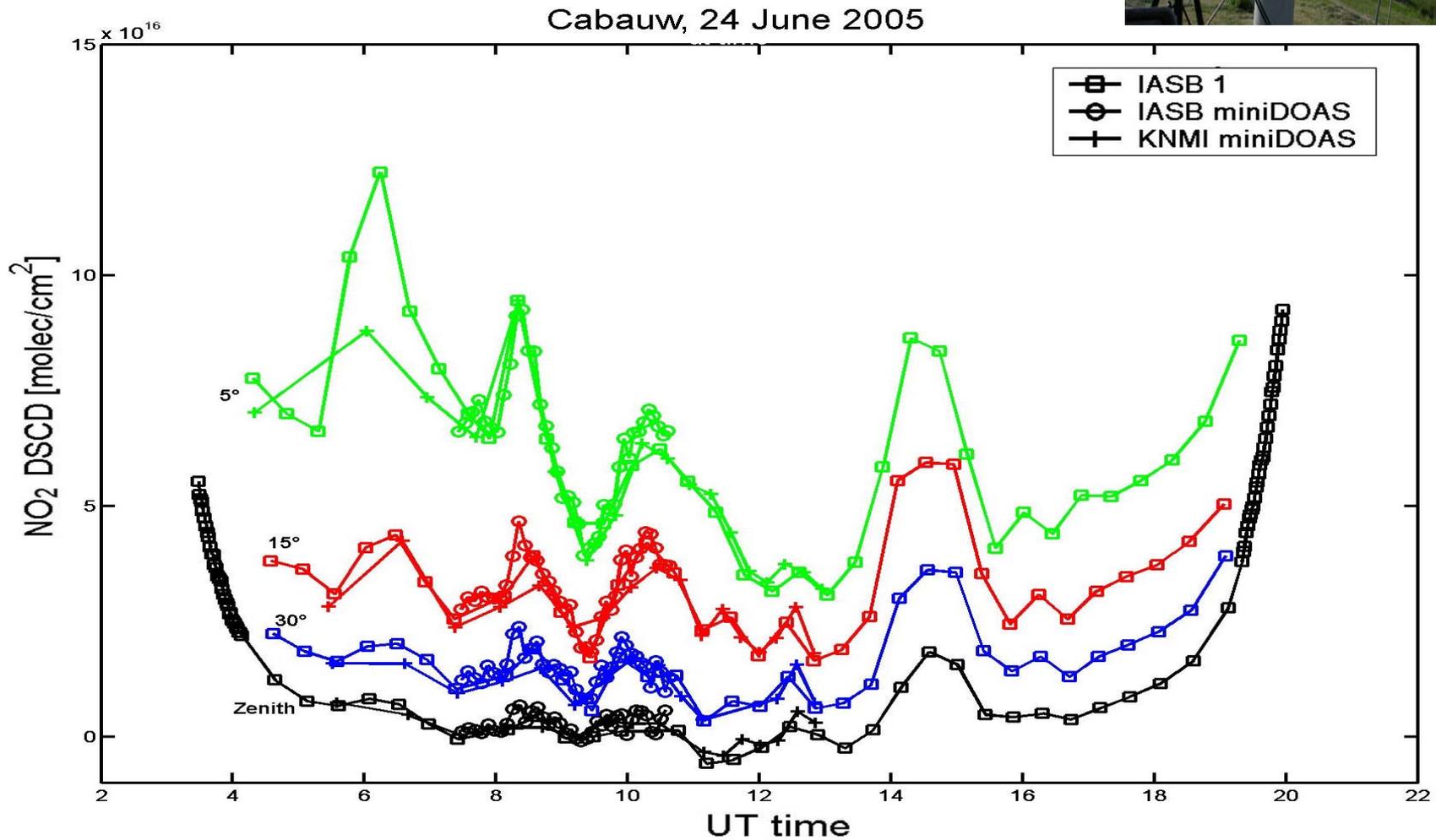


Comparison of one full elevation scan, as measured from the ground and from 220 m altitude. From the combination of both instruments, one expects increased information content for profile retrieval.



Mini MAX-DOAS

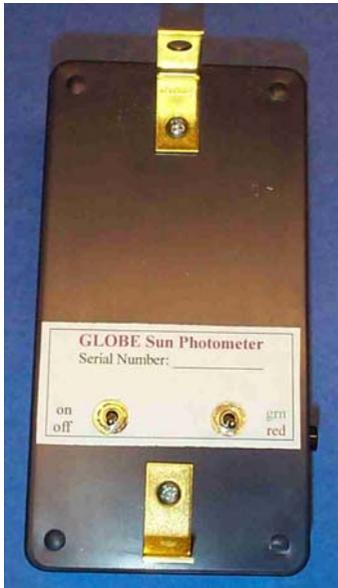
Comparison between two mini-DOASes and the BIRA MAX-DOAS, measuring side-by-side



DANDELIONS Aerosols

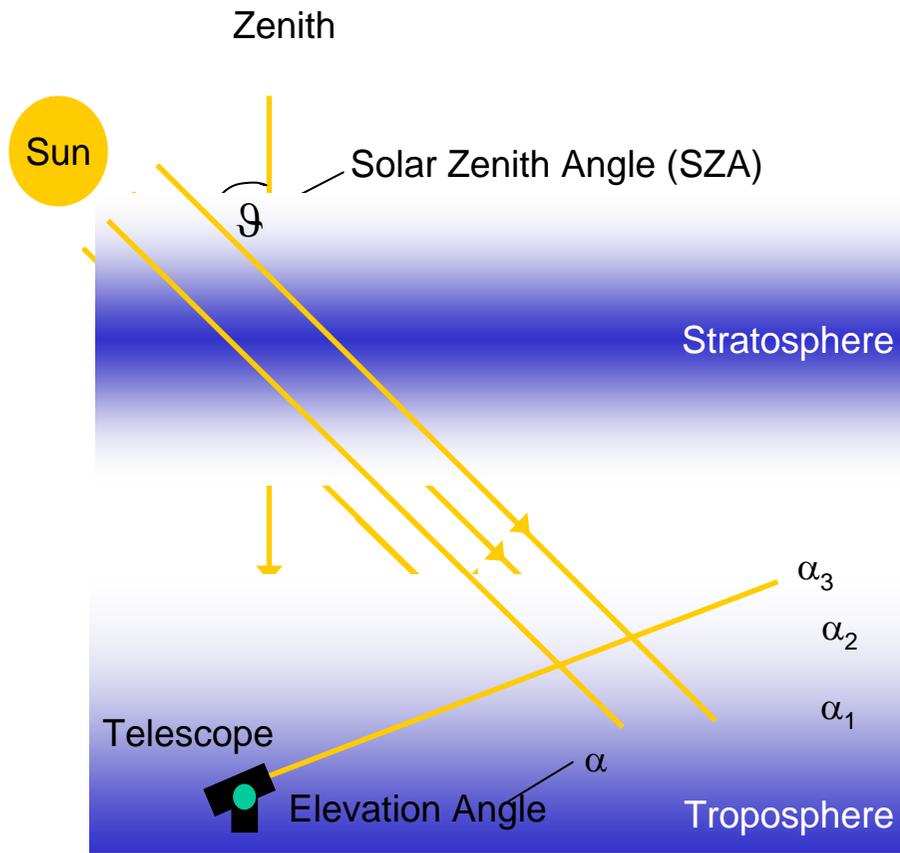
Aerosol instrumentation

- Validation of OMI, AATSR
- Various sun photometers (CIMEL, SPUV, Globe)
- Volatility system, aethalometer, 3-wavelength nephelometer, size distributions 10 nm – 10 μ m
- Tropospheric backscatter lidar
- Radio sondes (RH, T, P, for aerosol swelling with height)



MaxDOAS

MAX – DOAS = Multi – AXis – DOAS



- Measure solar spectra at different telescope elevations, light path length in the troposphere differs for different elevations
- DOAS method to retrieve daytime slant columns
- Relate to midday zenith spectrum & use airmass factors: tropospheric vertical columns
- **Optimal estimation: daytime 0-2.5 km vertical profiles can be derived**
- Twilight measurements used for stratospheric columns (conventional DOAS method)

Golden Days

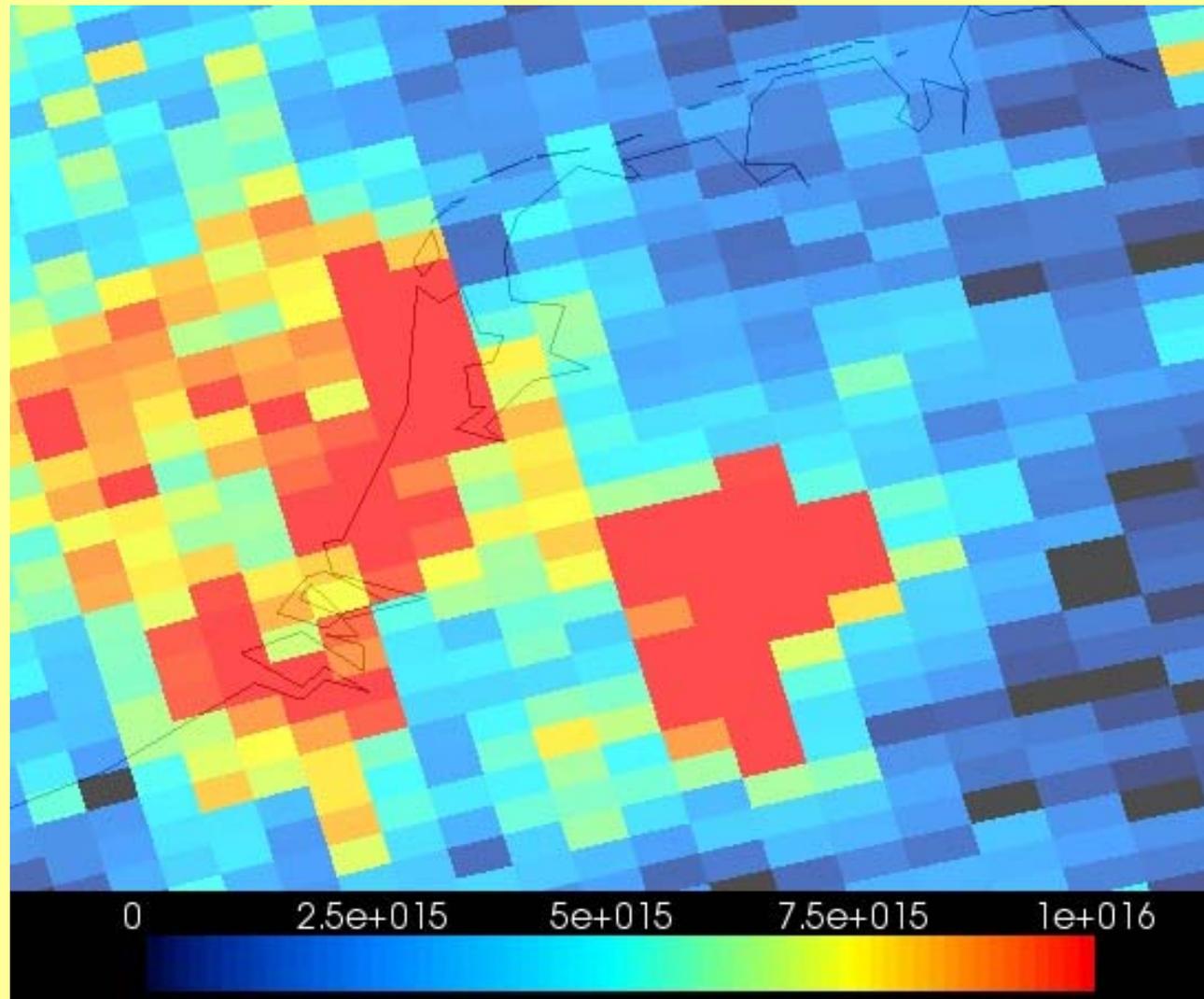
- May 27, 28: cloudless, high aerosol and NO₂ load (continental). See interesting change in lidar NO₂ profiles during May 28.
- June 19: cloudless, very clear – virtually no aerosols (BL lidar, Aeronet) or NO₂ (lidar). No ozone sonde from De Bilt.
- June 23: almost cloudless (little haze)
- June 24: milky blue sky and some cirrus. Very high aerosol loading (CIMEL)

Two other candidate days had cloud fractions 0.3 and 0.5

Two days with excellent weather were missed for logistic reasons

OMI tropospheric NO₂ on golden days

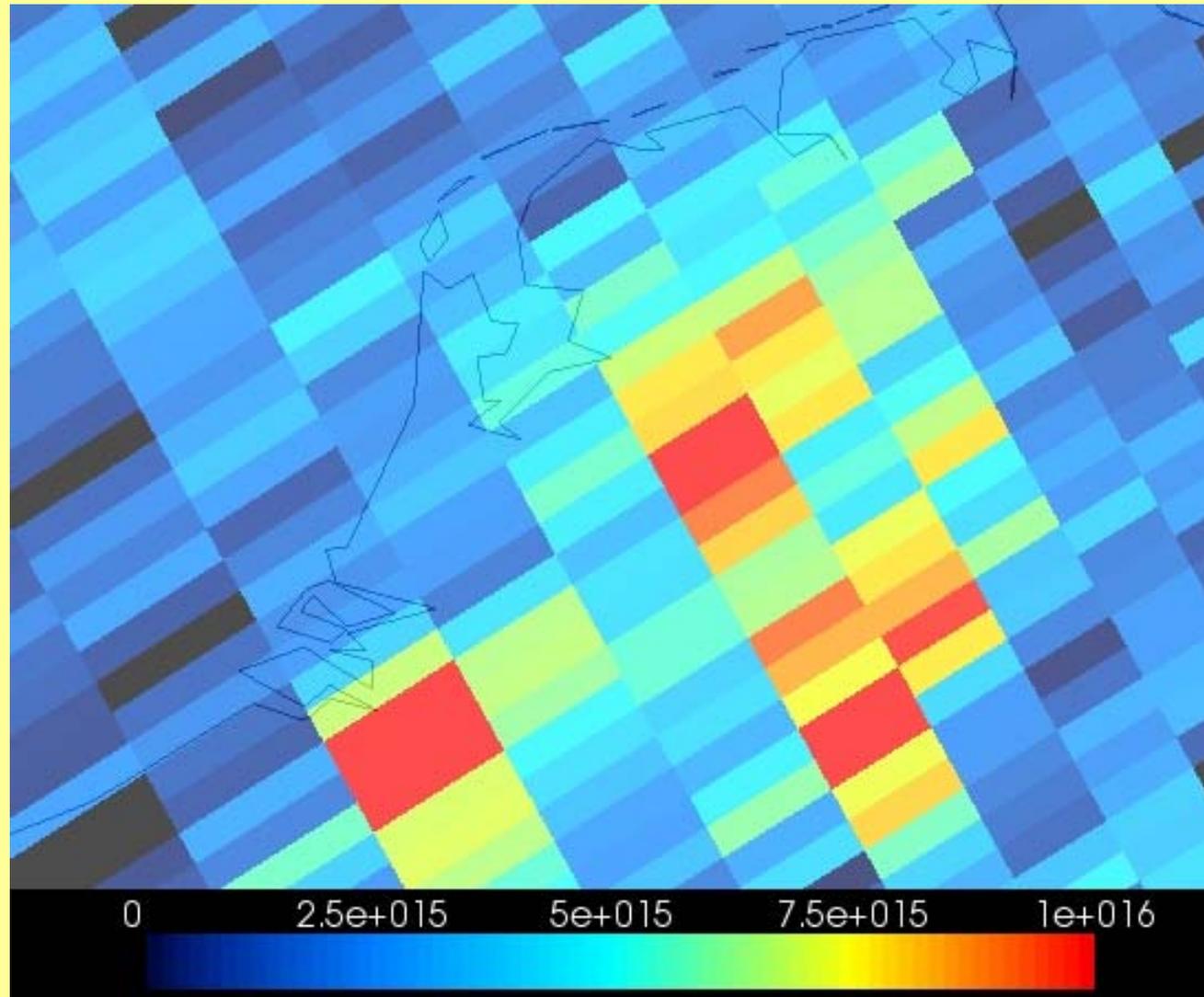
May 27



Pictures created using VISAN freeware (www.science-and-technology.nl)

OMI tropospheric NO₂ on golden days

May 28



Pictures created using VISAN freeware (www.science-and-technology.nl)